

HSMM

Communicating Voice, Video, and Data with Amateur Radio

New Amateur Digital Video (ADV) and Revolutionary HSMM-MESH® at Ham-Com

Ham-Com is the largest amateur radio convention in Texas. Given the size of this state, that is certainly saying something. It is successfully organized every year by a fine team of individuals led by John Beadles, N5OOM, of Richardson, Texas (see <<http://www.hamcom.org/>> and <<http://www.n5oom.org/hsmm/>>).

This year was special for HSMM (High-Speed Multimedia) radio experimenters. Glenn Currie, KD5MFW, Alexandre Castellane, F5SFU, and I got two full hours during prime-time Saturday afternoon to demo all the new firmware and hardware developments. It was a standing-room-only audience and we all had a great time.

I was the first presenter, explaining the usual differences between WiFi (FCC Part 15) and HSMM (FCC Part 97) radios operating using spread-spectrum modulation. We discussed the three main reasons why HSMM radio experimentation was started by Paul Renaldo, W4RI, ARRL CTO (Chief Technology Officer):

1. Amateur radio, particularly EmComm (this was just after 9/11), needed some means of data transmission significantly faster than conventional packet radio. HSMM radio can send the entire *ARRL Handbook* in under one minute, so it certainly fits that requirement.

2. Our service definitely needs to better utilize the big VHF and UHF frequency allocations we have been grant-

ed. Even bands considered “busy” are largely limited to commuting rush-hour activities, contest weekends, weekly nets, or occasional band-opening phenomena.

3. All of our EmComm served agencies are extensive users of wireless technology, while radio amateurs, “the communications experts,” know everything about radios except those which are the most popular in the world—WLAN transceivers and CDMA HTs! My beautiful wife Karen calls this a “time warp.... Hams use post WW II technology (AM, FM, SSB, RTTY, etc.), but seldom have any knowledge whatsoever regarding how the most common radios in the world operate!” Please don’t misunderstand me. All the legacy modes are great fun to operate. I have used them all, and I still do everyday. However, let’s not deceive ourselves about them being cutting-edge technology, nor the most popular two-way radio, nor certainly making us competition-grade communications experts.

To that list of these three rationales, many others would add a big fourth: We need to attract many more new and younger operators, if our service is to survive. Thus, we need to have modes such as “internet radios” (networked radios) that turn on the younger set.

We discussed the most frequent use of HSMM technology today—Field Day! Hardly any serious Field Day site is set up these days without some sort of intranet connection for common logging, etc. Also, a long-haul 2.4-GHz link is provided back to a ham’s home for internet access, if only to order pizza or to ask the family to deliver more cold soda, etc.

The second most common use of HSMM radio is repeater linking. It is the usual stuff many of you are very familiar with already. However, another form of that application is starting to grow quickly. As more D-STAR repeaters are installed, they are finding prime building sites but experiencing difficulty in acquiring their required internet access.

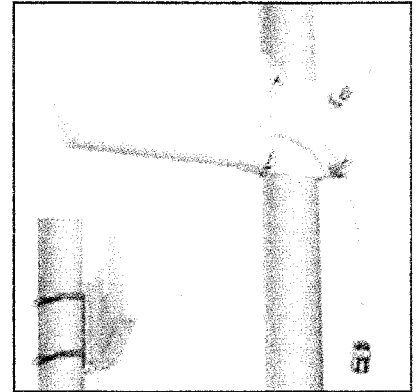


Photo A. My favorite personal pick for a new HSMM radio antenna this year is the ICOM Tri-Bander. In this photo the antenna is shown mounted in the vertical-polarization configuration. I recommend that it be reconfigured to horizontal polarization for the purpose of HSMM radio. (Photo courtesy of L-Com Global Connectivity, <<http://www.l-com.com>>)

Building owners are saying, “Sure you can have a nice free spot on our roof, but there is no way we will let you connect to our intranet to obtain internet access. Just forget that!”

Thus, HSMM radio provides a point-to-point to the nearest open internet access point.

Amateur Digital Video

At Ham-Com I explained the difference between ADV Amateur Digital Video) (which is internet-grade digital video using software coder-decoders over HSMM radio) and ATV (analog NTSC old, standard television). There is also DATV (new HDTV using hardware coders-decoders). OK, a no brainer, but give me a demo!

That is difficult in print, so for now, try this site: <<http://www.youtube.com/watch?v=sb4rhPILiC4>>. If you can do streaming video on the internet you can

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Note: HSMM-MESH® is the registered trademark of Glenn R. Currie, KD5MFW; Richard E. Kirchhof, III, NG5V; Robert B. Morgan, WB5AOH; and David B. Rivenburg, AD5OO. The term HSMM-MESH® is the property of these gentlemen and may not be used without recognition.

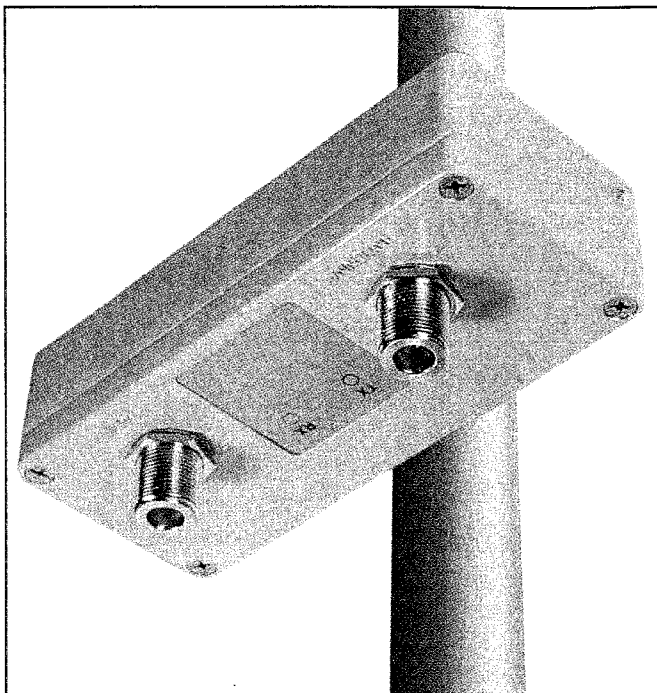


Photo B. The ICOM 3-watt bi-directional amplifier (BDA) with Automatic Power Control (APC). (Photo courtesy of L-Com Global Connectivity)

do it on HSMM. It is just that simple. But remember, on the air our amateur radio content rules still apply. Don't worry about pop-ups (you should have a pop-up blocker) and background music as long as they are merely incidental to your traffic, but no business!

As we have recommended numerous times on these pages, all HSMM radio station computers/laptops must be equipped with the latest anti-virus/anti-spyware protection (free programs are available) and be kept current. Also, use a software firewall of some type. Most computers come with a firewall. Just make certain it is enabled so that no changes can be made to your computer without your specific authorization.

HSMM Antenna Pick of the Year

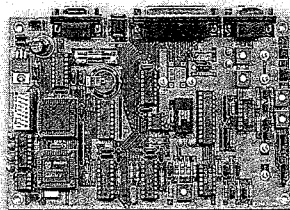
Excellent HSMM radio gear such as shown here is offered at reasonable prices and with good service by numerous distributors: FAB Corporation (<http://www.fabcorp.com/home.php>), L-Com Communications (<http://www.l-com.com>), and many others.

As for wireless routers such as the very popular Linksys WRT-54GL, try your local Goodwill store or similar used-electronics outlet. Why buy something new? You are going to hack into it anyway, right? These popular WiFi WLAN 2.4-GHz transceivers are available for about \$29.95 used. Stick to Linksys Models V1, V2, V2.1, V3, and V4, as these are capable of the HSMM-MESH® crystal hack we will cover in a future issue that allows for some VFO action.

My favorite personal pick for a new HSMM radio antenna this year is the ICOM Tri-Bander (photo A). It is a log-periodic design that covers the 2.4-, 3.5-, and 5.8-GHz bands! Also, it comes with a nice radome for protection from environmental effects. The manufacturer rates it at better than 6 dBi forward gain.

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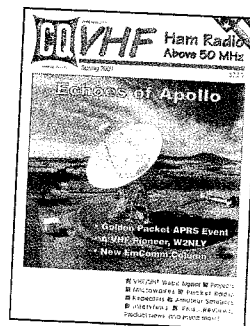
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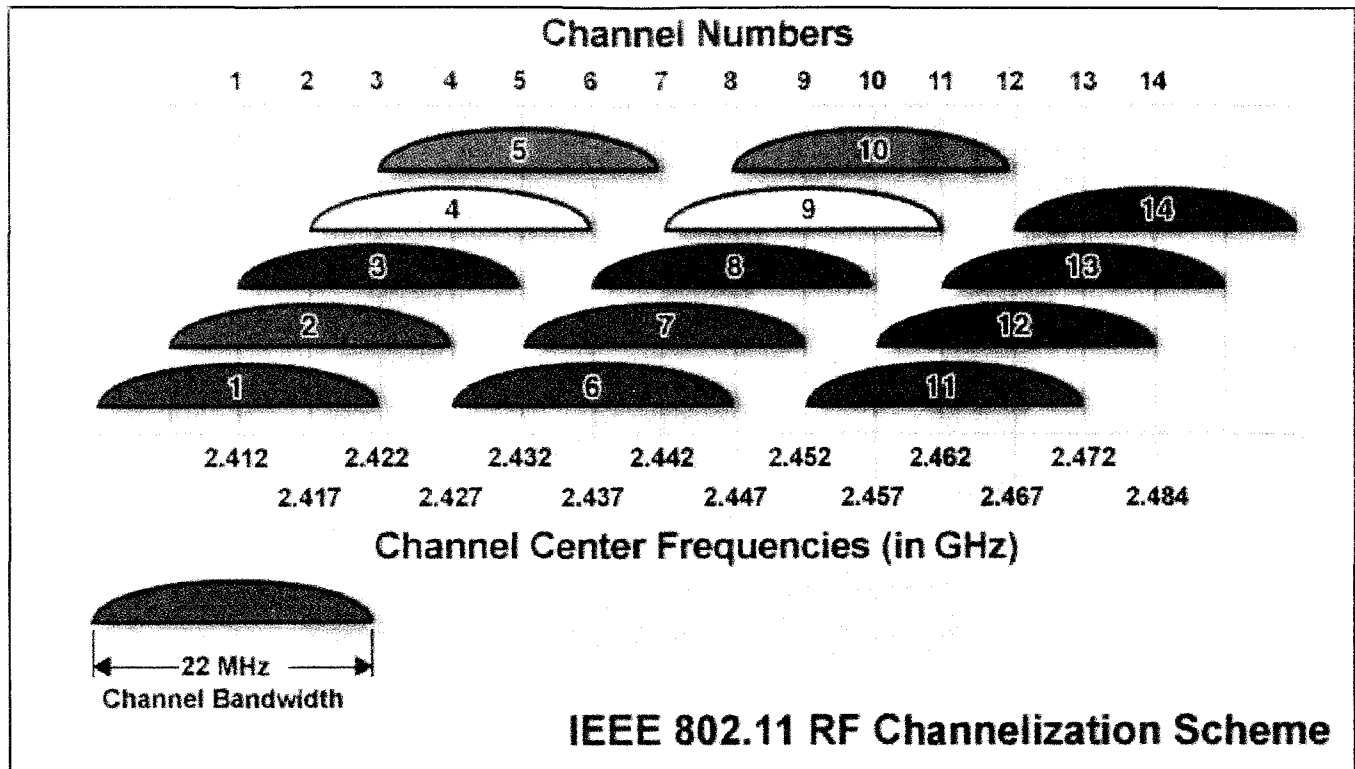


Figure 1. Channel center frequency chart. Some commercial Part 15 service providers use horizontal antennas for the same reason we radio amateurs often do. In that case, if you are operating in the same areas, you should coordinate closely with them regarding specific channel utilization. (Chart courtesy of L-Com Global Connectivity)

In the photo the antenna is shown mounted in the vertical-polarization configuration. I recommend that it be reconfigured to horizontal polarization for the purpose of HSMM radio. Not only does horizontal polarization seem to perform better than vertical polarization at these frequencies, but also using horizontal polarization will provide some slight isolation from the huge number of unlicensed Part 15 WiFi stations, the vast majority of which use vertical polarization. The only issue with using horizontal polarization is working HSMM radio mobile stations, most of which use phased collinear, high-gain, vertical, magnetic-mount antennas. Perhaps for some of us the M2 S-Band Stacked Horn, Sector Antenna (<http://www.m2inc.com/com/SBNDHORNFLY2.pdf>), or something similar homebrewed, may be a solution.

Also, some commercial Part 15 service providers use horizontal antennas for the same reason we radio amateurs often do. In that case, if you are operating in the same areas, you should coordinate closely with them regarding specific channel utilization. Yes, hams have the legal priority, but we always should try to be good neighbors. For example, at one location the local HSMM radio group coordinated with the Part 15 wireless commercial internet service provider (WISP) such that in the areas where they were both operating, the HSMM group used Channel 1 while the unlicensed commercial group used Channel 3. True, these are not completely non-overlapping channel assignments, but at least it prevented a portion of the possible destructive interference and allowed both groups to operate effectively in the same area. It certainly beats the usual college campus situation in which every single channel is in use! See the accompanying channel center frequency chart, figure 1, for additional details.

My personal favorite for new gear is another item also manufactured by ICOM: It is a 3-watt bi-directional amplifier (BDA) with Automatic Power Control (APC); see photo B. Now I know that the ARRL HSMM Working Group received notice from the FCC via the League's General Counsel that APC is no longer a requirement for hams under the Part 97 Spread Spectrum Rules. The FCC considers APC for hams—who often build their own equipment, including BDAs—"technologically impractical." However, this ICOM BDA has such a feature, which is supposed to provide some advantages. Besides lower power consumption, I have not figured out yet what those are. Perhaps an enlightened reader can let us know how a BDA works better with APC.

WARNING! It is illegal for you to connect this ICOM equipment to your WiFi Wireless Local Area Network (WLAN) router unless you are a licensed radio amateur under FCC Part 97 Regulations. If you are an unlicensed FCC Part 15 station and you connect this equipment to your WiFi WLAN you are subject to fines, confiscation, and imprisonment. Distributors of this equipment also have the right and responsibility to demand a copy of your FCC Radio Amateur license prior to any sale of this equipment to you. *You must be a licensed radio amateur to use this gear!*

More importantly, shocking new revolutionary developments in HSMM-MESH® networking make even reasonably priced BDAs such as this ICOM model less often necessary for most HSMM radio hams. See more details on HSMM-MESH® later.

It is somewhat similar to the classic question: "Do I need an amplifier?" The answer is if you have a good propagation path, you probably do *not* need a BDA. This reminds me of my

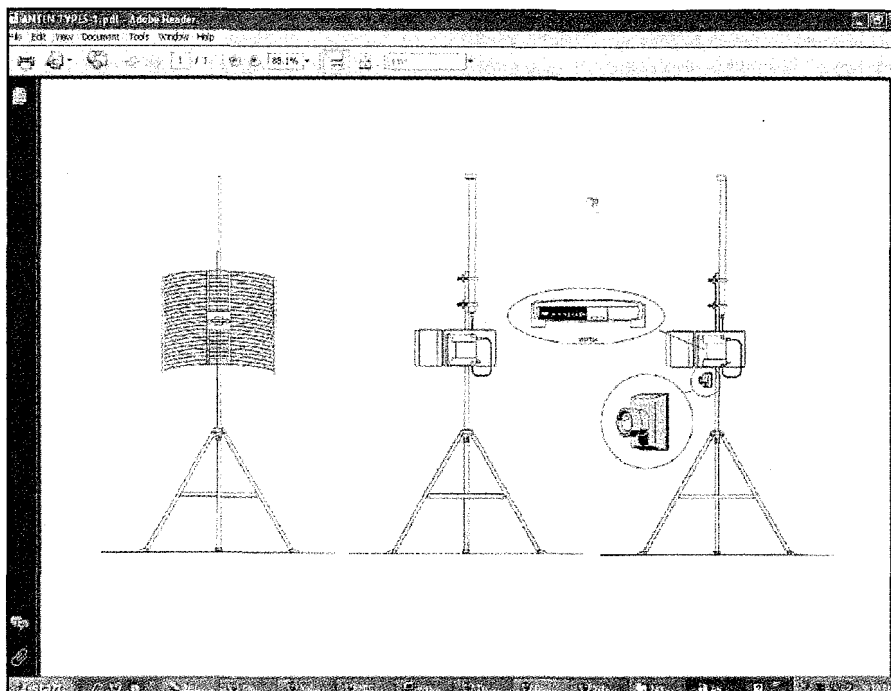


Figure 2. How a typical HSM-MESH® node is designed. The nodes are fully automatic and self-powered. (© 2009, Glenn R. Currie, KD5MFW)

DXpedition to Zimbabwe in southern Africa as Z2/K8OCL. I tried to check into a stateside HF DX net. They all were running big antenna arrays and powerful linear amplifiers. They all apparently could hear one another. I could easily and loudly hear nearly all of them. However, try as I might, with my 100-watt SSB rig and my dipole antenna, they could not hear me!

What is HSM-MESH® Networking?

Simply put, mesh networking is a form of digital communications that is designed to route data, voice, and instructions between nodes. This routing is accomplished by continuous connections and reconfiguration around broken or blocked paths by “hopping” from node to node until the destination is reached. Thus, HSM-MESH® networking is using HSM in a mesh network.

Glenn Currie, KD5MFW (kd5mfw@arrl.net) with the Austin HSM Special Interest Group (Austin HSM SIG) and the Roadrunners Microwave Group (RMG) was the second presenter at Ham-Com 2009. The presentation was dedicated to Glenn’s fine father, Job H. Currie, who recently passed away. Glenn’s session was a blockbuster.

Glenn immediately gave credit to all the fine organizations, and their mem-

bers, that are helping with the implementation and city-wide deployment of HSM-MESH® networked radios:

- The Austin Amateur Radio Club (<http://www.austinhams.org/>)
- The Roadrunner Microwave Group (<http://www.k5rmg.org/>)
- The North Texas Microwave Society (<http://www.ntms.org/>)
- The Austin HSM Special Interest Group (Travis County ARES SIG)
- The Travis County ARES (http://www.your-website-in-24-hours.com/travishams/tcares.org/index.php?option=com_content&task=view&id=17&Itemid=1)
- Williamson County ARES (<http://www.wc-ares.org/>)

Figure 2, the design, and photo C show a typical HSM-MESH® node. The nodes are fully automatic and self-powered. Any EmComm ham unfamiliar with HSM or microwave radio can transport the node to a designated site and simply turn it on. The rest is automatic! The node connects to the HSM-MESH® network and starts passing high-speed data traffic within a few seconds.

The Austin HSM Special Interest Group has developed hardware and software changes to make use of inexpensive 802.11 wireless computer networking radios but under Part 97 FCC rules. The major changes include:

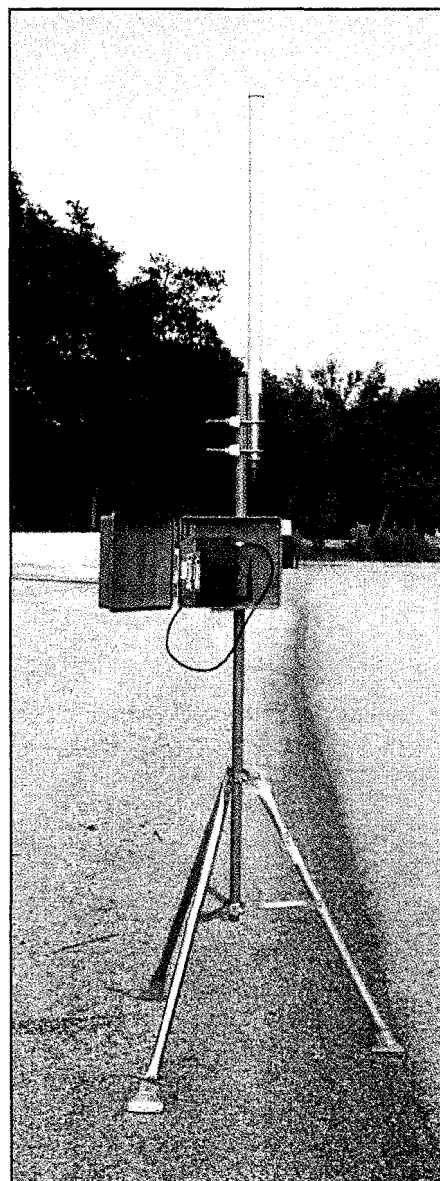


Photo C. This is typical stand-alone, omni-directional, fully automatic HSM-MESH® node. (Photo credit David B. Rivenburg, AD500)

- Range extended to 10–15 miles with good line of sight.
- Automatic address negotiation so radios link automatically with no user intervention within 5 seconds of coming into RF range of each other. We use Optimum Link State Routing (OLSR). See this link for more info: <www.olsr.org>.
- The RF section of the common Linksys WRT54GL Wireless Router has been modified so that only like-modified radios can see it. They are invisible to all Standard 802.11 radio devices.
- There are many new features in progress, but HSM-MESH® has

reached a point where it is being deployed to augment existing Amateur Radio Communications Healthcare Emergency Services (ARCHES) radio stations in the hospitals, Emergency Operation Centers (EOC), and the Red Cross in the Austin, TX area (photo D).

Background

Quote from the ARRL website:

"The Amateur Radio bands above 50 MHz can support computer-to-computer communications at speeds high enough to support multimedia applications.

"Multimedia in this case refers to voice, data and image communications.

"One approach that has been extensively explored is an adaptation of IEEE 802.11 technologies, particularly 802.11b operating in the 2400-2450 MHz band, known as the *Hinternet*.

"Also under the HSMM umbrella has been an orthogonal frequency division multiplex (OFDM) system developed by John Stephenson, KD6OZH, and tested on the 6-m band."

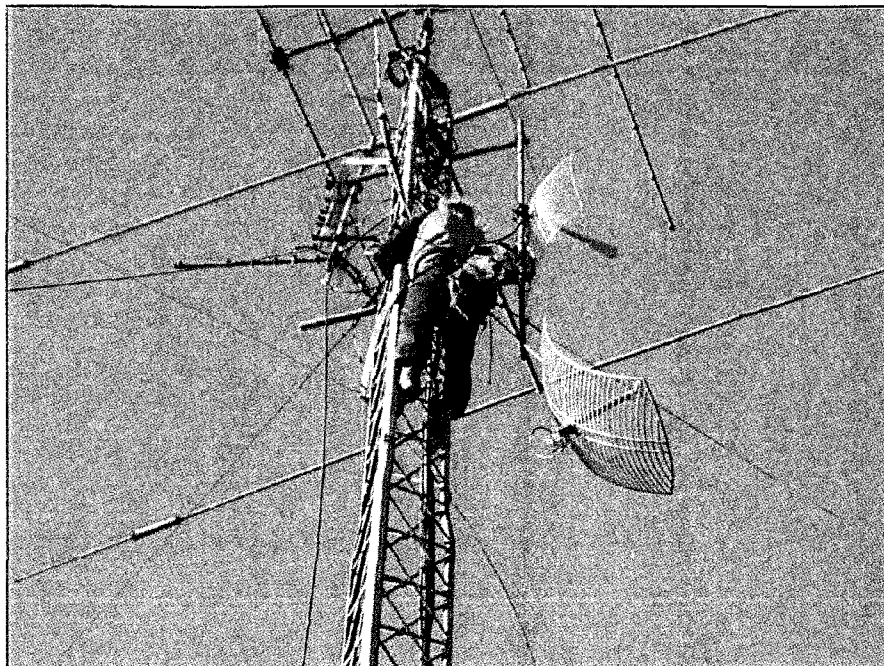


Photo D. This is Robert "Bob" Morgan, WB5AOH, mounting HSMM antennas on the Austin Texas Red Cross Tower, which is part of the AARC club station, W5KA. (Photo credit David, AD500)

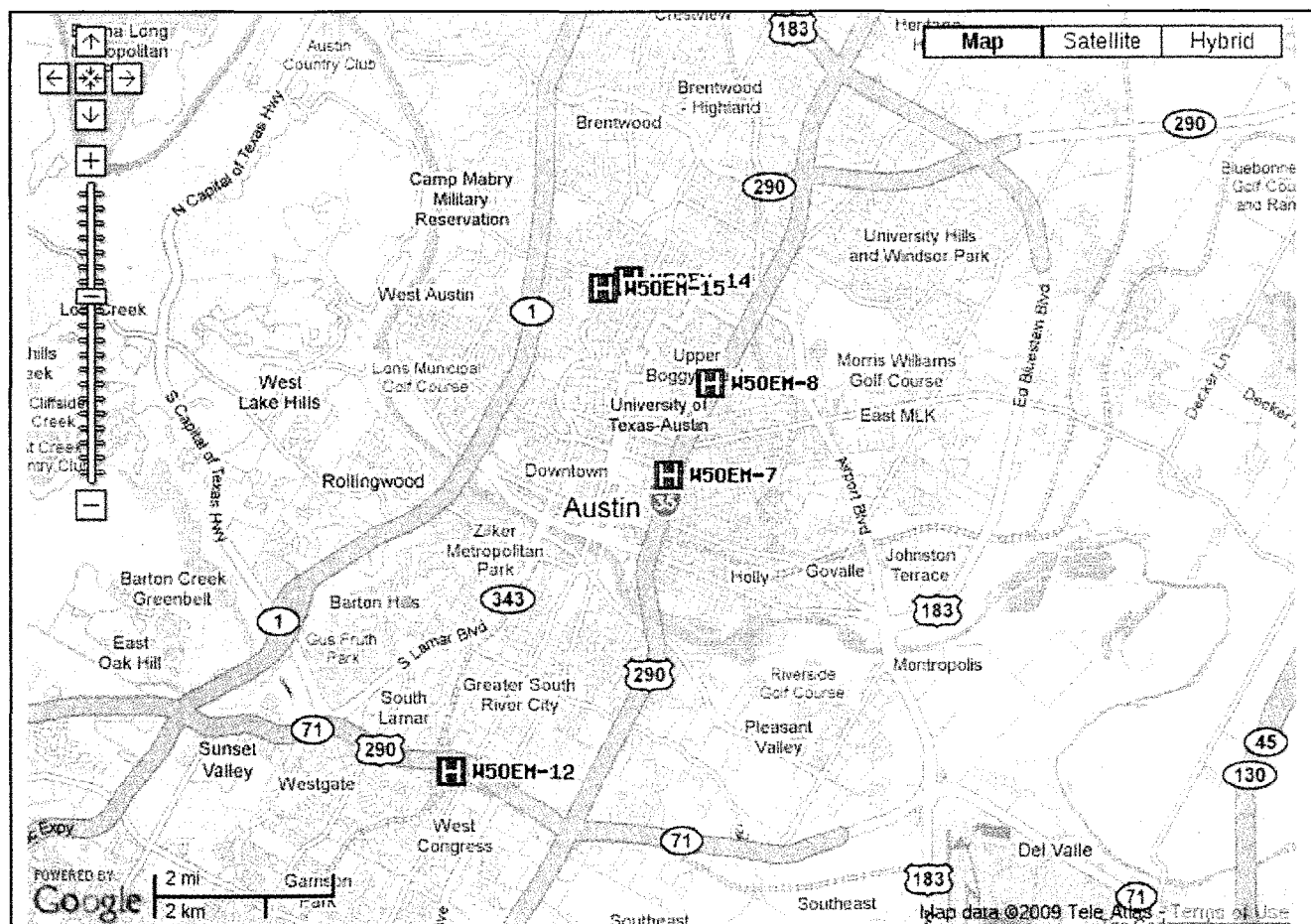


Figure 3. This map shows the hospitals that are online and help new operators find hospitals via internet maps. Go to <http://findu.com/> and do a wild-card search for stations W50EM-* and you will see the hospital stations.

(Editor's note: We would also add D-STAR 1.2-GHz HSMM radio to this list.)

Figure 3 is a map of all the ARCHES node equipped hospitals in Austin, TX. The highly successful ARCHES 2m/70cm voice and packet radios at nine Austin area hospitals provide key patient data to the City of Austin Emergency Operations Center during significant incidents even if normal communications are unavailable.

All ARCHES stations beacon on APRS every 20 minutes. If one of the monitor computers does not hear from a station for an hour, the operator in charge is paged, with an automated message that the automatic beacon has gone out at the hospital.

During every activation, patient data and other traffic passed more quickly and accurately than all other techniques tested during the activations. The ARCHES program has been so successful that hams have been asked to expand the system to

approximately 40 additional area hospitals and clinics in central Texas! Here is the crunch! During activations with just nine area hospitals, the EOC, and several portable "jump kits," all packet frequencies were more than full, leading to many collisions of packets. With 40 or more packet stations in the area, passing packet data could slow to a crawl due to packet collisions.

The stations could only transfer data at 1200 baud, at best. Attempts at using 9600 baud showed that common radios do not pass 9600-baud data well. They distort the data so badly that many resends are needed to get data through. The effective data rate seldom exceeds 1200 baud.

The obvious solution was to use an HSMM radio technique of adapting inexpensive Part 15 802.11 radios repurposed to use under Part 97. The question was could the necessary links be achieved in the Austin area. The answer: AD500,

NG5V, and KD5MFW achieved a 10-mile point-to-point link across downtown Austin using only 35 mw (photo E)! Figure 4 is a sample map of the open routes that were found on the 2.4 GHz band.

Photo F shows a North Austin Mobile HSMM radio test site. Note the ubiquitous MFJ-1800 antenna. They work extremely well but must be protected by a thin plastic radome when used outside in permanent installations.

The secret of HSMM-MESH® success is in the use of OLSR (Optimal Links State Routing). OLSR is state-of-the-art mobile networking software. Andreas Tonnesen wrote the version of OLSR software being used for his Master's thesis. He wrote the code and made it to run on the Linksys WRT54G Wireless router. It is written on top of Open-WRT firmware for several reasons: Andreas suggested keeping track of one- and two-hop neighbor mesh nodes, not *all* mesh nodes in the network. The trick is to

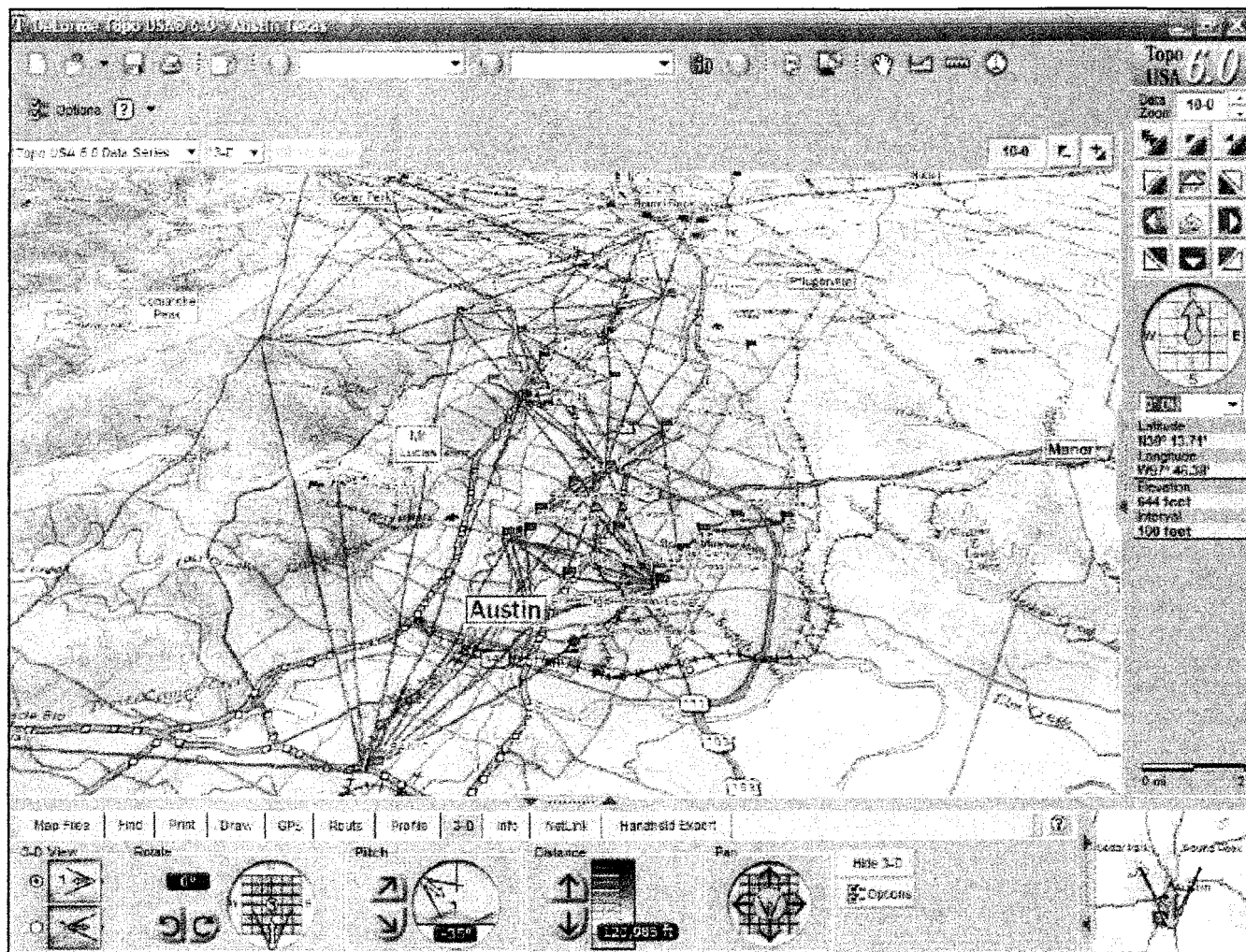


Figure 4. This is a sample of Glenn's use of DeLorme Topo USA© to plot potential microwave routes for HSMM-MESH® in the Austin area.

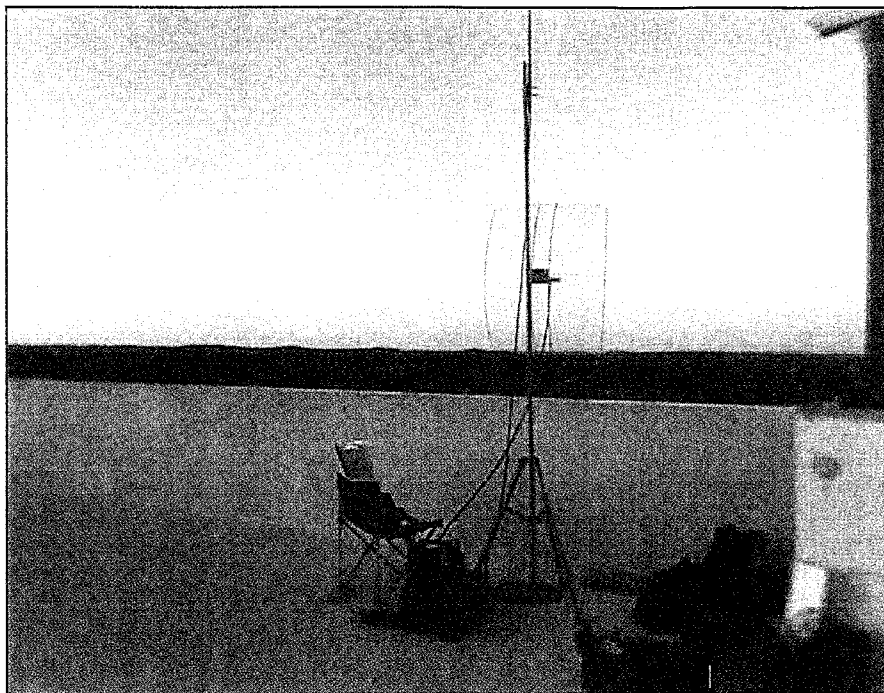


Photo E. Shooting to AD500 on the north side of town over the heavily populated University of Texas, Austin campus area showing 35 mw can go 10 miles over thousands of access points and microwave ovens in between. This is an HSMM radio test site at the South Austin Medical Center. (Photo credit Glenn Currie, KD5MFW)

update the routing table list about every 2 seconds. This allows nodes to come and go as conditions allow. They will be linked and passing data in 5 seconds when in RF range. Absolutely no user interaction is needed! If a link is lost, data is automatically rerouted through other nodes, again with no user interaction.

HSMM "VFO" Crystal, or the "Slide-Band" Radio Mod

Crystal frequency change makes it impossible for standard 802.11 devices to connect with an HSMM-MESH® "slide band" radio network. The tests showed that by making a simple 59-cent crystal change the HSMM signals could be moved to between IEEE Channels 2–3.

Figure 5 is from Wi-SPY® by Meta-Geek (<http://metageek.com>). The yellow shaded area shows the official 802.11 Channel 2 center. The red shaded section shows the official 803.11 Channel 11. Glenn had one crystal-modified Linksys WRT54G and one unmodified Linksys WRT54G. He then directed the software for both of them to go to Channel 11.

The CPU clock and ethernet clocks are totally different from the radio crystal, so both units "think" they are on Channel 11. Only the crystal-modified "slide band" unit is somewhere between

Channels 2 and 3 as shown by the green and blue accumulated readings. Both units were tested for about 3 hours for frequency stability, etc.

The Wi-SPY spectrum analyzer cannot follow the slide band as it goes much lower in frequency out of the ISM band. Glenn put it on Channel 11 so he could

see the slide band with this inexpensive spectrum analyzer. The shift was right on the money of what the crystal-modification calculations predicted. This frequency shift makes the HSMM-MESH® signal completely invisible to Part 15 stations, and even to WiFi search engines such as NetStumbler (<http://www.netstumbler.com/>). The signal is totally WiFi stealth! The only way the signal is detected is by using a spectrum analyzer.

Wow! Now we have it: A complete ham radio (Part 97) inexpensive spread-spectrum transceiver on 2.4 GHz with different frequency(s), different antennas, and different firmware. The Hinternet has arrived!

ADV Demonstration

Alexandre Castellane, F5SFU, conducted the highlight of the entire Ham-Com 2009 HSMM 2-hour presentation with his Amateur Digital Video (ADV) live demonstration. Alexandre had pre-positioned four HSMM-MESH® battery-powered/fully-automatic nodes throughout the huge Plano Convention Center. Using free streaming video software and an inexpensive web cam, Alexandre was able to walk through the entire complex while we watched his progress in the meeting room via this mini-Hinternet arrangement. The mesh nodes functioned perfectly. Each time Alexandre walked out of range of one node with its simple rubber-duck antenna, his streaming video traffic would

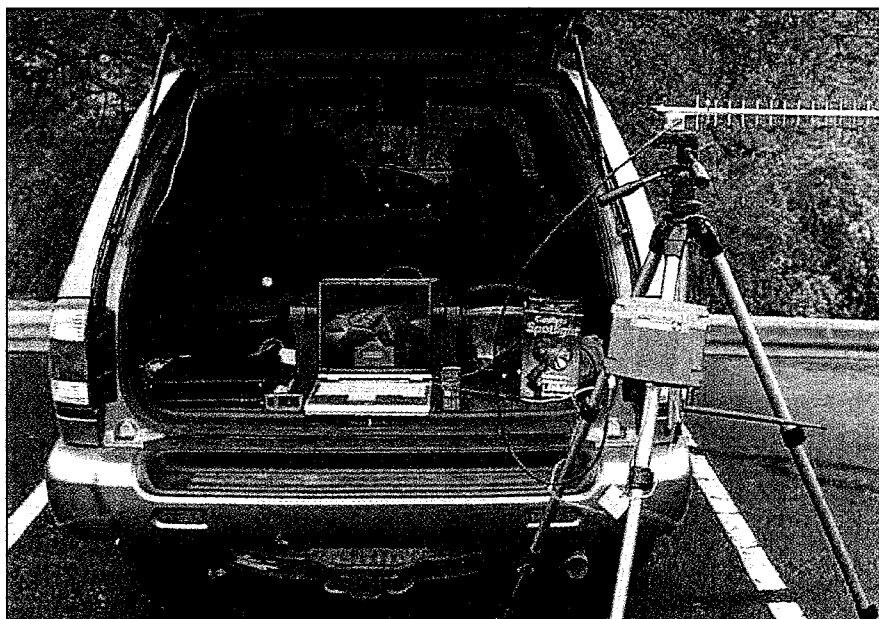


Photo F. David, AD500/HSMM mobile with his trusty MFJ-1800 antenna. (Photo credit AD500)

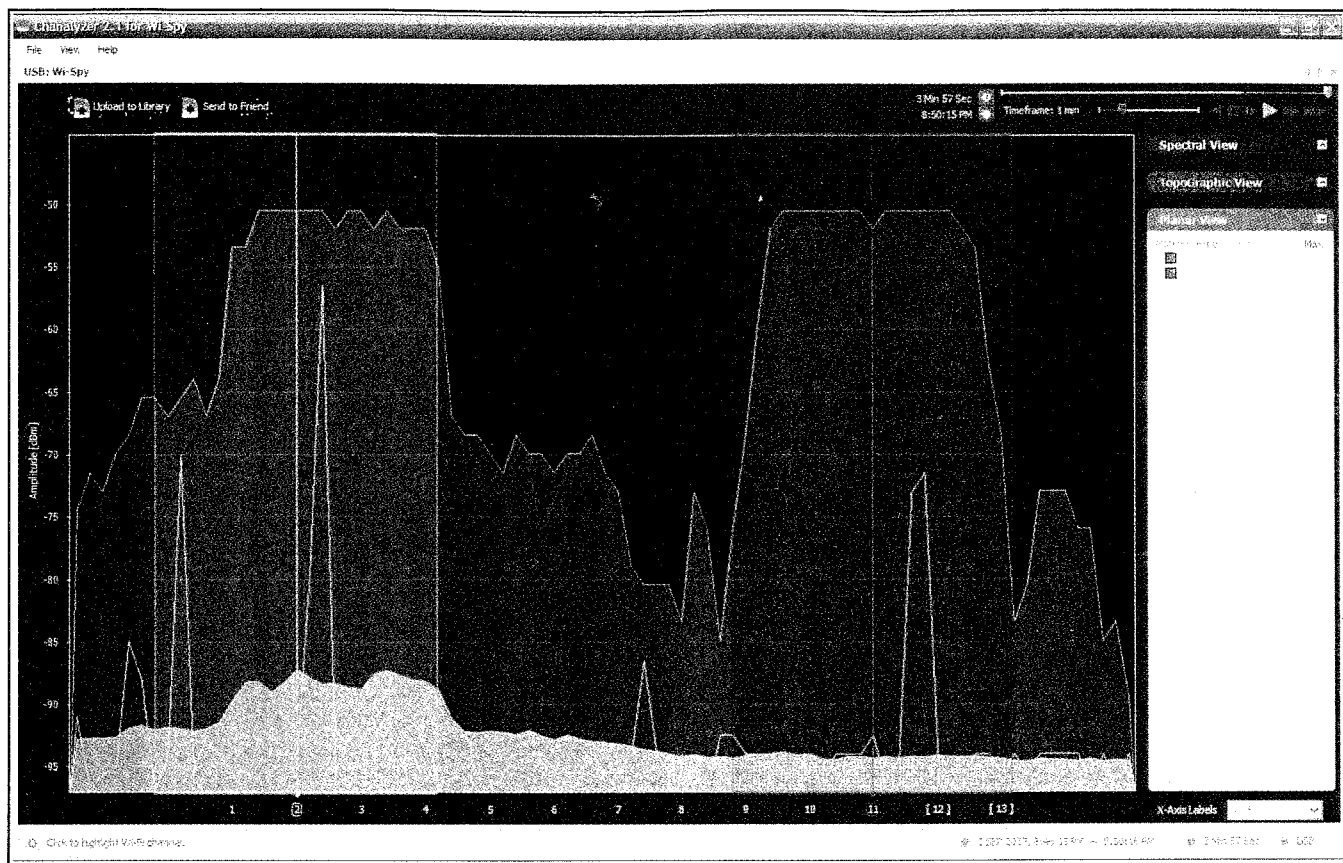


Figure 5. This spectrum analysis is from Wi-SPY® by MetaGeek (<http://metageek.com>). The yellow shaded area shows the official 802.11 Channel 2 center. The red shaded section shows the official 802.11 Channel 11.

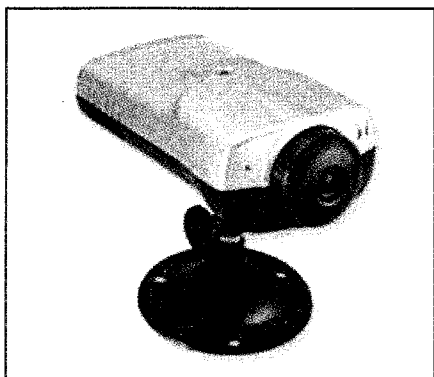


Photo G. A typical inexpensive web cam purchased used for \$39.95. (Photo credit Glenn, KD5MFW)

automatically be relayed to the next node. It was stunning to watch!

Photo G shows a typical inexpensive web cam purchased used for \$39.95. John, K8OCL, uses one he purchased new at the Dayton Hamvention® that is even smaller and sold for even less. Couple this with some free video streaming software such as Microsoft NetMeeting® and you are on ADV! Hope to see you soon!

Until next time, feel free to write with your questions and comments to: <k8ocl@arrl.net> or <kd5mfw@arrl.net>.

73, John, K8OCL

References

HSMM references in order of preference for getting started. All of these are available from the ARRL Book Store: <<http://www.arrl.org/catalog/?category=Digital+Communications&words=>>>.

ARRL's *VHF Digital Handbook*, by Steve Ford, WB8IMY. Without complicated "owner's manual" jargon this book presents the material through a unique how-to approach and friendly, conversational style. Readers will understand how to setup and operate their equipment and software, and make the best use of their VHF digital station. Contents include: Packet Radio Fundamentals, APRS, D-STAR, High Speed Multimedia, Digital Meteor Scatter and Moonbounce, Technical Descriptions, plus digital applications in public service and emergency communications.

Building Wireless Community Networks, 2nd Edition, by Rob Flickenger. This book is about getting people online using wireless network technology. The 802.11b standard (also known as WiFi) makes it possible to network towns, schools, neighborhoods, small

business, and almost any kind of organization. The first edition of this book helped thousands of people engage in community networking activities. This revised and expanded edition adds coverage on new network monitoring tools and techniques, regulations affecting wireless deployment, and IP network administration, including DNS and IP Tunneling. (182 pages. Second edition, © 2003, published by O'Reilly & Associates, Inc.)

802.11 Wireless Networks: The Definitive Guide, by Matthew S. Gast. Creating and administering wireless networks. Wireless networks are also more flexible, faster and easier for you to use, and more affordable to deploy and maintain. The de facto standard for wireless networking is the 802.11 protocols, which include Wi-Fi (the wireless standard known as 802.11b) and its faster cousin, 802.11g. But it's wise to be familiar with both the capabilities and risks associated with the 802.11 protocols. This book the perfect place to start and is designed with the system administrator or serious home user in mind. It's a no-nonsense guide for setting up 802.11 on Windows and Linux. Among the wide range of topics covered are discussions on: deployment considerations, network monitoring and performance tuning, wireless security issues, how to use and select access points, network monitoring essentials, wireless card configuration, and security issues unique to wireless networks.